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13. ABSTRACT *(Maximum 200 words)*

The Spacewatch program discovers small bodies (asteroids and comets) in the solar system and analyzes their distributions with orbital parameters and absolute magnitude. Scanning of the night sky is conducted 18-20 nights per month with the 0.9-m Spacewatch Telescope on Kitt Peak. About 1200 to 2000 square degrees of sky are searched each year to a V magnitude limit of 21.5. Spacewatch discoveries support studies of the evolution of the Centaur, Trojan, Main-Belt, and Earth-approaching asteroid populations. Spacewatch also finds potential targets for space missions, finds objects that might present a hazard of impact on the Earth, provides accurate astrometry of about 30,000 asteroids annually, and recovers comets and asteroids that are too faint for most other observers. This AASERT grant supported several undergraduate students working on upgrades to instrumentation and analyses of data under the supervision of Spacewatch engineers and researchers. The opportunity to have young, energetic new members of the group accomplished a great deal of work, stimulated and accelerated our research efforts, and enhanced the students' career opportunities.

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from the
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Augmentation Awards for Science and Engineering Research Training Program
(AASERT)

Title: **Students in Advanced Research for Sky Surveillance**

Grant No.: **AFOSR F49620-93-1-0499**

Grant Dates: 1 September 1993 - 31 October 1997

Principal Investigator: **Tom Gehrels**

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Agency's Technical Point of Contact: **Dr. Henry R. Radoski**
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Contributions of AASERT-funded students, in alphabetical order:

Jason Fields wrote code for telescope motion control models and ran errands for the Spacewatch Lab group and the telescope builders. He has since moved on to another position at LPL.

Steve Goisman constructed the absolute-encoder microcontroller system for the 1.8-meter Spacewatch Telescope under the supervision of Staff Engineer Marcus Perry. Steve also worked with Electronic Technician Terry Bressi on motion control system design, helping to build a 3-motor test bed (for the three azimuth motors) in the lab to test with software and hardware design. Steve left the Spacewatch Project in December 1996 when he obtained his Master's Degree in Engineering.

Jon D. Herron worked under the supervision of Research Associate Robert Jedicke to complete their paper entitled "Observational Constraints on the Centaur Population". One of the difficulties associated with this task was running 100,000 simulated Centaur-type orbits through a simulation of the Spacewatch observing program, incorporating all of the efficiencies and scanning patterns of 2.5 years of data. The code was written quickly but at first it took a week to run each simulation! Refinements by Herron eventually made it possible to run a simulation over night. This allowed the code to be run numerous times to test Spacewatch sensitivity to assumed orbital distributions of the Centaurs. Herron left the Spacewatch group for a position in private industry when he graduated in May 1996.

Travis S. Metcalfe was a critical link in developing techniques and code required to calculate the observational bias inherent to the Spacewatch data. He and Research Associate Robert Jedicke did the first ever model-independent bias calculation for asteroid surveys and applied it to Spacewatch observations. This research required characterizing the limiting magnitude, asteroid detection efficiency, losses due to trailing of the object's image during an exposure, etc. Metcalfe quickly measured these important parameters. In the process, he confirmed that the pre-coma-corrected Spacewatch calibration system was excellent (within 0.01 magnitudes of accepted stellar standards), found a correction associated with the reported magnitudes for saturated stellar images, and measured the post-coma-corrector magnitude calibration system. Metcalfe graduated with a degree in Astronomy in May 1996. He is now an astronomy graduate student at the University of Texas in Austin.

Aaron Schultz worked with Senior Research Specialist Jim Scotti to archive the unique collection of P/Shoemaker-Levy 9 images obtained between March 1993 and July 1994 by Spacewatch observers. He wrote Fortran programs to convert the data to FITS format, then wrote these data on CD-ROMS to be sent to the Planetary Data System. Schultz also processed some archival Spacewatch data to look for bright Trans-Neptunian objects (TNO's). He left the Spacewatch Project voluntarily in December 1996.

Andrew Tubbiolo, also an undergraduate student, has been working under Marcus Perry's supervision. His tasks have been focused around computer systems, electronics, and mechanical hardware associated with the 0.9-m and 1.8-m Spacewatch Telescopes.

Currently the project uses a mix of Unix, Linux, NT, and MS/DOS machines. Andrew has tied all these together over a network to work harmoniously with the rest of the LPL and Kitt Peak mountain domains. Andrew added a second workstation at the 0.9-m telescope (a PC named "pholus" running the "linux" operating system). Since this one is not committed to processing and display of realtime observations, it allows the observer to do other important things without interrupting the data collection. These tasks include email about recently discovered objects, looking at- and processing data collected earlier, and accessing the 'web for information about objects discovered by other groups during the observing run.

The Spacewatch Project is currently defining its next generation computer system. Andrew has participated in the ongoing discussion as to what platform, operating system, and network configuration will be used on the 1.8-m Spacewatch Telescope. At issue is what platform will best serve the data analysis requirements, and what type of network will be used to move the data and archive it. Also at issue are development tools, development time, and overall cost of the system. This type of system may eventually be used as an upgrade to the 0.9-m Spacewatch Telescope as well.

Andrew has helped with the many assorted tasks of final construction of the 1.8-meter telescope. His primary work has been the two cable wraps needed to transfer power and signals between the instrumentation on the telescope and the control room.

Due to errors made by a sub-contractor, a new 2048×2048 CCD camera is undergoing some modifications. Andrew helped document these errors and contacted a new contractor to quickly make a layout and fabricate new CCD controller boards. The new CCD system makes use of field programmable logic arrays to bring down chip count and power consumption. Andrew helped obtain the equipment needed to support a wide variety of Altera logic devices. That hardware and software is now installed and ready to to be used by the Spacewatch Project.

In conclusion, we thank Dr. Henry Radoski for encouraging us to take on students. Spacewatch has become well known for its successful work with these young people.

Publications Supported by Students' Efforts:

Gehrels, T., Herron, J. D., Jedicke, R., McMillan, R. S., Metcalfe, T. S., Montani, J. L., Nichol, J., & Scotti, J. V. 1996. Spacewatch Survey for Trans-Neptunian Objects (abstract). *Bull. A. A. S.* **28,** 1081.

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